CERES TRMM-PFM-VIRS Edition2B SSF
Surface Fluxes - Accuracy and Validation

One of the principal objectives for the CERES data products is to provide improved estimates of surface fluxes (net and downward) for shortwave (SW) and longwave (LW) radiation. To achieve this objective, considerable effort has been focused upon obtaining consistent fluxes at the surface, within the atmosphere, and at the top of the atmosphere, all of which are produced as part of the CERES CRS data product using the Edition2B SSF as input data. Initial CRS surface fluxes, however, will not be available until Summer 2002. A second effort, therefore, uses much simpler algorithms either:

- to directly tie surface fluxes to broadband CERES TOA fluxes such as in Li et al. (1993) and Darnell et al. (1992) for SW fluxes, and Inamdar and Ramanathan (1997) for clear-sky LW surface fluxes.
- or to use simple radiative parameterizations (Gupta 1989 and Gupta, Darnell, and Wilber 1992) to estimate surface fluxes, especially for the case of surface downward LW fluxes which are effectively decoupled from the TOA fluxes for cloudy sky conditions.

These simpler SSF surface flux parameterizations are, therefore, more comparable to results used in past analyses of surface radiation data sets based on ERBE or geostationary data. In general, however, they are not expected to be as precise as the CERES CRS surface fluxes, though they do represent an independent method to get to the more difficult surface flux estimates.

The CERES SSF data product provides 4 surface flux algorithm results:

1. Shortwave Flux Model A, Daytime only, Clear-sky only
    - Net surface fluxes use Li et al. (1993).
    - Downward surface fluxes use Li et al. (1993) for net and Li and Garand (1994) for surface albedo.
2. Shortwave Flux Model B, Daytime only, Clear and All-sky
    - Net and downward surface fluxes use the Langley Parameterized Shortwave Algorithm (LPSA) (Darnell et al. 1992; Gupta et al. 1999).
3. Longwave Flux Model A, Daytime and Nighttime, Clear-sky only
    - Net and downward surface fluxes uses Inamdar and Ramanathan (1997).
4. Longwave Flux Model B, Daytime and Nighttime, Clear and All-sky
    - Net and downward surface fluxes use the Langley Parameterized Longwave Algorithm (LPLA) (Gupta 1989 and Gupta, Darnell, and Wilber 1992).

For the Edition2B surface fluxes, clear-sky has been defined as a CERES footprint with an imager determined cloud cover percentage less than 0.1%. Thus, to be consistent with the angular distribution models, our validation effort has also taken clear-sky to be defined as a CERES footprint with an imager determined cloud cover percentage less than 0.1%.

The SSF surface fluxes are being validated using both theoretical analyses and simultaneous matching of satellite data to a range of surface sites. Preliminary results are discussed in the sections which follow.

The CERES SSF surface flux estimates were obtained using Tropical Rainfall Measuring Mission (TRMM) satellite data for January through August of 1998. The precession cycle of the TRMM satellite is such that for any specified geolocation the CERES instrument can make measurements over the entire diurnal cycle every 46 days. The coincident surface fluxes were then gathered from 19 sites (The Central Facility along with 18 of the Extended Facilities) in the Atmospheric Radiation Measurement (ARM) Southern Great Plains (SGP) network, 2 sites (Bermuda and Kwajalein) in the Climate Modeling and Diagnostic Laboratory (CMDL) network, and 3 sites (Alice Springs, Florianopolis and Tateno) in the Baseline Surface Radiation Network (BSRN). Unless otherwise noted, surface site fluxes are 1 minute averages and are compared to the CERES footprint which includes the surface site.

Clear-sky Shortwave Downward Flux Validation: Model A and B

For the shortwave, two models have been used to produce the surface fluxes. Both of these shortwave models are part of our validation effort; however, Model A produces fluxes only for clear-sky conditions while Model B produces fluxes for both clear and all-sky conditions.

Validation studies of the TRMM Edition 2A surface fluxes demonstrated that shortwave Model A overestimated surface insolation at the ARM Central Facility by approximately 30 W m^{-2}. Considering that such biases were not observed for pristine high-latitude surface sites, it was hypothesized that the effects of aerosols could be the cause. Thus, an aerosol correction factor based on the Masuda et al. (1995) method and using the GFDL climatological aerosols (Haywood et al., 1999) was incorporated into shortwave Model A. As can be seen from the following table for the clear-sky case, the use of the Masuda et al. (1995) method with the GFDL climatological aerosols has resulted in a significant improvement to shortwave Model A. When shown the results of our validation studies, the principal author of Model A (Z. Li) approved our modifications to that model.

A follow-on investigation has uncovered an error in the application of the GFDL aerosols used to compute the TRMM SW model A fluxes. This error, which is most notable over the Arabian Sea and the southwest Indian Ocean, has been corrected within the algorithm used to compute the Terra and Aqua SW model A fluxes. This corrected algorithm will also be used for any future computation of the TRMM SW model A fluxes.

The following tables for the clear-sky cases also illustrate that both shortwave Models A and B are found to be in reasonably good agreement with the surface measurements at the ARM/CART SGP sites. As compared to the measured surface fluxes, however, Model A still tends to yield a small overestimation (positive bias) while Model B tends to yield a small underestimation (negative bias). At the CMDL and BSRN sites somewhat larger errors are found between the surface fluxes derived from satellite data and the measured surface fluxes. These remaining discrepancies are under investigation.

Downward Shortwave Model A Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	55	8.89 W m^{-2}	26.07 W m^{-2}	24.51 W m^{-2}
Arm Extended Facilities	815	13.99 W m^{-2}	28.10 W m^{-2}	24.37 W m^{-2}
BSRN Facilities	108	1.14 W m^{-2}	47.24 W m^{-2}	47.23 W m^{-2}
CMDL Facilities	31	49.69 W m^{-2}	61.84 W m^{-2}	36.93 W m^{-2}

Downward Shortwave Model B Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	55	-18.00 W m^{-2}	26.97 W m^{-2}	20.08 W m^{-2}
Arm Extended Facilities	815	-12.02 W m^{-2}	24.13 W m^{-2}	20.92 W m^{-2}
BSRN Facilities	108	-26.74 W m^{-2}	45.96 W m^{-2}	37.38 W m^{-2}
CMDL Facilities	31	11.29 W m^{-2}	39.45 W m^{-2}	37.80 W m^{-2}

Preliminary results are presented for the all-sky Model B case. To reduce the considerable variance introduced by broken cloud fields, the surface data have been averaged over the 60 minutes centered on the time of the satellite overpass. Note, the variance introduced by broken cloud fields is far greater than that introduced by the temporal averaging. Other discrepancies which contribute to the variance are still under investigation.

Downward Shortwave Model B Comparisons, All-Sky, 60 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	149	-8.70 W m^{-2}	49.08 W m^{-2}	48.30 W m^{-2}
Arm Extended Facilities	2087	9.64 W m^{-2}	61.93 W m^{-2}	61.18 W m^{-2}
BSRN Facilities	321	6.68 W m^{-2}	72.20 W m^{-2}	71.89 W m^{-2}
CMDL Facilities	353	34.41 W m^{-2}	93.79 W m^{-2}	87.25 W m^{-2}

Clear-sky Longwave Downward Flux Validation: Model A

Longwave Model A uses CERES-derived window and non-window TOA fluxes as well as the meteorological profiles to obtain surface fluxes for clear sky conditions. As demonstrated by the following table, the results from longwave Model A are found to be in good agreement with the surface measurements for all the sites that were considered. It should be noted that a significant modification was applied to longwave Model A between the production of TRMM Edition 2A and 2B. This modification now allows for global ocean and land application of Model A for clear-sky conditions.

Downward Longwave Model A Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	129	-2.03 W m^{-2}	18.62 W m^{-2}	18.51 W m^{-2}
ARM Extended Facilities	1932	-3.04 W m^{-2}	24.11 W m^{-2}	23.92 W m^{-2}
BSRN Facilities	209	-0.55 W m^{-2}	25.57 W m^{-2}	25.56 W m^{-2}
CMDL Facilities	97	-10.37 W m^{-2}	16.65 W m^{-2}	13.03 W m^{-2}

Theoretical studies and validation studies employing data from Central Equatorial Pacific Experiment (CEPEX), reported by Inamdar and Ramanathan (1997), are consistent with our results. The parameterization over land surfaces was initially developed using a limited set of emissivity data available from IRIS measurements aboard NIMBUS 4 (Prabhakara and Dalu 1976). The current version of longwave Model A, however, was developed using the global emissivity maps developed by Wilber et al. (1999) and thus can be applied to the extra-tropics as well as to the tropics. Other possible sources of errors include:

1. Specification of the true radiating temperature (especially land surfaces);
2. Errors in scene identification;
3. Emissions from aerosols in the boundary layer. For instance, Inamdar and Ramanathan (1997) noted that sensitivity studies had revealed that thick haze in the boundary layer (visibilities less than 15 km) could increase the downward emissions by about 3 - 5 W m^{-2}.

All-sky Longwave Downward Flux Validation: Model B

Longwave Model B uses the meteorological profiles and CERES VIRS-derived cloud properties, but not the CERES-derived TOA fluxes, to obtain surface fluxes for clear and all-sky conditions. As demonstrated by the following tables, the results from longwave Model B are found to be in good agreement with the surface measurements at all the sites.

Downward Longwave Model B Comparisons, Clear-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	129	-1.65 W m^{-2}	17.35 W m^{-2}	17.27 W m^{-2}
Arm Extended Facilities	1932	-4.86 W m^{-2}	20.76 W m^{-2}	20.18 W m^{-2}
BSRN Facilities	209	-12.46 W m^{-2}	19.47 W m^{-2}	14.96 W m^{-2}
CMDL Facilities	97	-10.65 W m^{-2}	17.49 W m^{-2}	13.87 W m^{-2}

Downward Longwave Model B Comparisons, All-Sky, 1 min data

Site	# of Points	Mean Bias	RMS Difference	Standard Deviation
ARM Central Facility	917	-0.05 W m^{-2}	18.84 W m^{-2}	18.84 W m^{-2}
Arm Extended Facilities	4470	-2.30 W m^{-2}	20.92 W m^{-2}	20.79 W m^{-2}
BSRN Facilities	574	-9.76 W m^{-2}	18.75 W m^{-2}	16.01 W m^{-2}

CMDL Facilities	790	-7.20 W m^{-2}	18.53 W m^{-2}	17.07 W m^{-2}

The error statistics given in the above tables, especially for the ARM central facility and extended facilities represent realistic estimates of the instantaneous errors present in the retrieved fluxes. Nevertheless, while the results are very encouraging, it is critical that longer term comparisons be made to improve the statistics of the results and to resolve outstanding issues.

Return to Quality Summary for: Edition2B | Edition2B-TransOps